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SEARCH REQUEST FORM Scientific and Technical Information Center - EIC2800

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Date 8/14/02. Serial # ______ Priority Application Date ______

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08-14-02 P02:48 OUT

What is the topic, such as the **novelty**, motivation, utility, or other specific facets defining the desired **focus** of this search? Please include the concepts, synonyms, keywords, acronyms, registry numbers, definitions, structures, strategies, and anything else that helps to describe the topic. Please attach a copy of the abstract and pertinent claims.

WHAT IS THE ELASTICITY OF ZIRCONIA AND SODIUM SILICATE AT 25°C.

Staff Use Only

Searcher: Derrick Blalock
Searcher Phone: 306-0935
Searcher Location: STIC-EIC2800, CP4-9C18
Date Searcher Picked Up: 8/15/02
Date Completed: 8/15/02
Searcher Prep/Rev Time: 0
Online Time: 180

Type of Search

Structure (#) ______
Bibliographic ______
Litigation ______
Fulltext ______
Patent Family ______
Other ✓

Vendors

STN ______
Dialog ______
Questel/Orbit ______
Lexis-Nexis ______
WWW/Internet ✓
Other ✓

Element Information: Thorium

Thorium

90
Th
232.0381

Atomic Number	90
Atomic Weight	232.0381
Electron Config.	2-2-6-2-6-10-2-6-10-14-2-6-10-0-2-6-2-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	11700 kg/m^3	Solid	298.15	0
Poisson Ratio	0.27	Solid		
Thermal Expansion Coefficient	1.100×10^{-5} /K	Solid	298.15	

Electrical Properties		Conditions	
		Temp. (K)	**Note**

		Conditions	
Electrical Resistivity	1.300×10^{-7} Ω-m	273.15	
Thermal Properties		**Temp.** (K)	**Pressure** (Pa)
Melting Temperature	2023.15 K		101325
Boiling Temperature	5061.15 K		101325
Critical Temperature	14400 K		
Fusion Enthalpy	59.5 J/g	0	101325
Heat Capacity	113 J/kg-K	298.15	100000
Thermal Conductivity	54 W/m-K	300	101325

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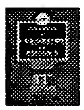

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Element Information: Palladium

Palladium

46	Atomic Number	46
Pd	Atomic Weight	106.42
106.42	Electron Config.	2-2-6-2-6-10-2-6-10

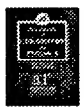
Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	12000 kg/m^3	Solid	298.15	0
Modulus of Elasticity	110.316 GPa	Solid	0	
Poisson Ratio	0.39	Solid		
Thermal Expansion Coefficient	1.180×10^{-5} /K	Solid	298.15	

Electrical Properties **Conditions**

		Temp. (K)	Note
Electrical Resistivity	1.080×10^{-7} Ω-m	293.15	

Thermal Properties		Conditions Temp. (K)	Conditions Pressure (Pa)
Melting Temperature	1828.05 K		101325
Boiling Temperature	3236.15 K		101325
Critical Temperature	7700 K		
Fusion Enthalpy	157.3 J/g	0	101325
Heat Capacity	244 J/kg-K	298.15	100000
Thermal Conductivity	71.8 W/m-K	300	101325



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Element Information: Uranium

Uranium

92
U
238.0289

Atomic Number	92
Atomic Weight	238.0289
Electron Config.	2-2-6-2-6-10-2-6-10-14-2-6-10-3-2-6-1-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		**Conditions**		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	19100 kg/m^3	Solid	298.15	0
Modulus of Elasticity	165.474 GPa	Solid	0	
Poisson Ratio	0.23	Solid		
Thermal Expansion Coefficient	1.390×10^{-5} /K	Solid	298.15	

Electrical Properties **Conditions**

		Temp. (K)	Note
Electrical Resistivity	3.000×10^{-7} Ω-m		chrystallographic average

Thermal Properties		**Conditions**	
		Temp. (K)	**Pressure** (Pa)
Melting Temperature	1408.15 K		101325
Boiling Temperature	4404.15 K		101325
Critical Temperature	12500 K		
Fusion Enthalpy	38.4 J/g	0	101325
Heat Capacity	116 J/kg-K	298.15	100000
Thermal Conductivity	27.6 W/m-K	300	101325

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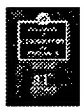

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Element Information: Calcium

Calcium

20	Atomic Number	20
Ca	Atomic Weight	40.078
40.078	Electron Config.	2-2-6-2-6-0-2

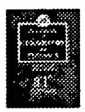
***Electron configuration order:** 1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	1540 kg/m^3	Solid	298.15	0
Modulus of Elasticity	27.579 GPa	Solid	0	
Poisson Ratio	0.31	Solid		
Thermal Expansion Coefficient	2.230×10^{-5} /K	Solid	298.15	

Electrical Properties **Conditions**

		Temp. (K)	N te
Electrical Resistivity	3.910×10^{-8} Ω-m	273.15	

Thermal Properties		Conditions	
		Temp. (K)	Pressure (Pa)
Melting Temperature	1115.15 K		101325
Boiling Temperature	1757.15 K		101325
Critical Temperature	4300 K		
Fusion Enthalpy	213 J/g	0	101325
Heat Capacity	647 J/kg-K	298.15 more...	100000
Thermal Conductivity	200 W/m-K	300	101325



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Element Information: Va

Vanadium

23 V 50.9415		
	Atomic Number	23
	Atomic Weight	50.9415
	Electron Config.	2-2-6-2-6-3-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Pres
Density	6000 kg/m^3	Solid	298.15	
Modulus of Elasticity	131 GPa	Solid	0	
Poisson Ratio	0.37	Solid		
Thermal Expansion Coefficient	8.400×10^{-6} /K	Solid	298.15	

Electrical Properties		Conditi
		Temp. (K)
Electrical Resistivity	2.540×10^{-7} Ω-m	293.15

Thermal Properties		Conditions	
		Temp. (K)	Press
Melting Temperature	2183.15 K		10
Boiling Temperature	3680.15 K		10
Critical Temperature	11300 K		
Fusion Enthalpy	422 J/g	0	10
Heat Capacity	489 J/kg-K	298.15 more...	10
Thermal Conductivity	30.7 W/m-K	300	10

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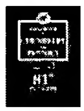

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Element Information: Ta

Tantalum

73 Ta 180.9479		
	Atomic Number	73
	Atomic Weight	180.9479
	Electron Config.	2-2-6-2-6-10-2-6-10-14-2-6-3-0-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Pres
Density	16400 kg/m^3	Solid	298.15	
Modulus of Elasticity	186.159 GPa	Solid	293.15	
Poisson Ratio	0.34	Solid		
Thermal Expansion Coefficient	6.300×10^{-6} /K	Solid	298.15	

Electrical Properties		Conditi
		Temp. (K)
Electrical Resistivity	1.245×10^{-7} Ω-m	298.15

Thermal Properties		Conditions	
		Temp. (K)	Press
Melting Temperature	3290.15 K		10
Boiling Temperature	5731.15 K		10
Critical Temperature	16500 K		
Fusion Enthalpy	202.1 J/g	0	10
Heat Capacity	140 J/kg-K	298.15 more...	10
Thermal Conductivity	57.5 W/m-K	300	10

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Element Information: I

Niobium

41 Nb 92.90638		
	Atomic Number	41
	Atomic Weight	92.90638
	Electron Config.	2-2-6-2-6-10-2-6-4-0-1

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Pres
Density	8570 kg/m^3	Solid	298.15	
Poisson Ratio	0.4	Solid		
Thermal Expansion Coefficient	7.300×10^{-6} /K	Solid	298.15	

Electrical Properties		Conditi
		Temp. (K)
Electrical Resistivity	1.250×10^{-7} Ω-m	273.15

Thermal Properties		Conditions	
		Temp. (K)	Pressu
Melting Temperature	2750.15 K		101
Boiling Temperature	5017.15 K		101
Critical Temperature	12500 K		
Fusion Enthalpy	323 J/g	0	101
Heat Capacity	265 J/kg-K	298.15	100
Thermal Conductivity	53.7 W/m-K	300	101

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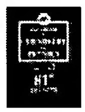

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Element Information: B

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Beryllium

4 **Be** 9.012182	Atomic Number	4
	Atomic Weight	9.012182
	Electron Config.	2-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Pres
Density	1850 kg/m^3	Solid	298.15	
Modulus of Elasticity	289.58 GPa	Solid	0	
Thermal Expansion Coefficient	1.130×10^{-5} /K	Solid	298.15	

Electrical Properties		Condition	
		Temp. (K)	
Electrical Resistivity	4.000×10^{-8} Ω-m	293.15	a

Table 6.1.9 Basic Properties of Several Metals
(Staff contribution)*

Material	Density,† g/cm^3	Coefficient of linear thermal expansion,‡ in/(in · °F) × 10^{-6}	Thermal conductivity, Btu/(h · ft · °F)	Specific heat,‡ Btu/(lb · °F)	Approx melting temp, °F	Modulus of elasticity, $lb/in^2 \times 10^6$	Poisson's ratio	Yield stress, $lb/in^2 \times 10^3$	Ultimate stress, $lb/in^2 \times 10^3$	Elongation, %
Aluminum 2024-T3	2.77	12.6	110	0.23	940	10.6	0.33	50	70	18
Aluminum 6061-T6	2.70	13.5	90	0.23	1,080	10.6	0.33	40	45	17
Aluminum 7079-T6	2.74	13.7	70	0.23	900	10.4	0.33	68	78	14
Beryllium, QMV	1.85	6.4–10.2	85	0.45	2,340	40–44	0.024–0.030	27–38	33–51	1–3.5
Copper, pure	8.90	9.2	227	0.092	1,980	17.0	0.32		See "Metals Handbook"	
Gold, pure	19.32		172	0.031	1,950	10.8	0.42		18	30
Lead, pure	11.34	29.3	21.4	0.031	620	2.0	0.40–0.45	1.3	2.6	20–50
Magnesium AZ31B-H24 (sheet)	1.77	14.5	55	0.25	1,100	6.5	0.35	22	37	15
Magnesium HK31A-H24	1.79	14.0	66	0.13	1,100	6.4	0.35	29	37	8
Molybdenum, wrought	10.3	3.0	83	0.07	4,730	40.0	0.32	80	120–200	Small
Nickel, pure	8.9	7.2	53	0.11	2,650	32.0	0.31§		See "Metals Handbook"	
Platinum	21.45	5.0	40	0.031	3,217	21.3	0.39		20–24	35–40
Plutonium, alpha phase	19.0–19.7	30.0	4.8	0.034	1,184	14.0	0.15–0.21	40	60	Small
Silver, pure	10.5	11.0	241	0.056	1,760	10–11	0.37	8	18	48
Steel, AISI C1020 (hot-worked)	7.85	6.3	27	0.10	2,750	29–30	0.29	48	65	36
Steel, AISI 304 (sheet)	8.03	9.9	9.4	0.12	2,600	28	0.29	39	87	65
Tantalum	16.6	3.6	31	0.03	5,425	27.0	0.35		50–145	1–40
Thorium, induction melt	11.6	6.95	21.7	0.03	3,200	7–10	0.27	21	32	34
Titanium, B 120VCA (aged)	4.85	5.2	4.3	0.13	3,100	14.8	0.3	190	200	9
Tungsten	19.3	2.5	95	0.033	6,200	50	0.28		18–600	1–3
Uranium D-38	18.97	4.0–8.0	17	0.028	2,100	24	0.21	28	56	4

Room-temperature properties are given. For further information, consult the "Metals Handbook" or a manufacturer's publication.
* Compiled by Anders Lundberg, University of California, and reproduced by permission.
† To obtain the preferred density units, kg/m^3, multiply these values by 1,000.
‡ See also Tables 6.1.10 and 6.1.11.
§ At 25°C.

PHYSICAL PROPERTIES OF THE RARE EARTH METALS (continued)

Table 11
Room Temperature Elastic Moduli and Mechanical Properties

Rare earth metal	Elastic moduli (GPa) Young's (elastic) modulus	Shear modulus	Bulk modulus	Poisson's ratio	Mechanical properties (MPa) Yield strength 0.2% offset	Ultimate tensile strength	Uniform elongation (%)	Reduction in area (%)	Recryst. temp. (°C)
Sc	74.4	29.1	56.6	0.279	173[a]	255[a]	5.0[a]	8.0[a]	550
Y	63.5	25.6	41.2	0.243	42	129	34.0	—	550
αLa	36.6	14.3	27.9	0.280	126[a]	130	7.9[a]	—	300
βCe	—	—	—	—	86	138	—	24.0	—
γCe	33.6	13.5	21.5	0.24	28	117	22.0	30.0	325
αPr	37.3	14.8	28.8	0.281	73	147	15.4	67.0	400
αNd	41.4	16.3	31.8	0.281	71	164	25.0	72.0	400
αPm	46[b]	18[b]	33[b]	0.28[b]	—	—	—	—	400[b]
αSm	49.7	19.5	37.8	0.274	68	156	17.0	29.5	440
Eu	18.2	7.9	8.3	0.152	—	—	—	—	300
αGd	54.8	21.8	37.9	0.259	15	118	37.0	56.0	500
αTb	55.7	22.1	38.7	0.261	—	—	—	—	500
αDy	61.4	24.7	40.5	0.247	43	139	30.0	30.0	550
Ho	64.8	26.3	40.2	0.231	—	—	—	—	520
Er	69.9	28.3	44.4	0.237	60	136	11.5	11.9	520
Tm	74.0	30.5	44.5	0.213	—	—	—	—	600
βYb	23.9	9.9	30.5	0.207	7	58	43.0	92.0	300
Lu	68.6	27.2	47.6	0.261	—	—	—	—	600

Note: For additional information, see Scott, T., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1, Gschneidner, K.A., Jr. and Eyring, L., Eds., North-Holland Physics, Amsterdam, 1978, 591.

[a] Value is questionable.
[b] Estimated.

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Element Information: Cerium

Cerium

58
Ce
140.115

Atomic Number	58
Atomic Weight	140.115
Electron Config.	2-2-6-2-6-10-2-6-10-1-2-6-1-0-2

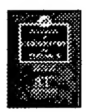
Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		**Conditions**		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	8160 kg/m^3	Solid	298.15	0
Modulus of Elasticity	41.369 GPa	Solid	313.15	
Poisson Ratio	0.24	Solid		
Thermal Expansion Coefficient	5.200×10^{-6} /K	Solid	298.15	

Electrical Properties **Conditions**

		Temp. (K)	Note
Electrical Resistivity	7.500×10^{-7} Ω-m	298.15	

Thermal Properties		**Conditions** Temp. (K)	Pressure (Pa)
Melting Temperature	1072.15 K		101325
Boiling Temperature	3697.15 K		101325
Critical Temperature	9750 K		
Fusion Enthalpy	39 J/g	0	101325
Heat Capacity	192 J/kg-K	298.15	100000
Thermal Conductivity	11.3 W/m-K	300	101325



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Element Information: Barium

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Barium

56
Ba
137.327

Atomic Number	56
Atomic Weight	137.327
Electron Config.	2-2-6-2-6-10-2-6-10-0-2-6-0-0-2

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	**Temp.** (K)	**Pressure** (Pa)
Density	3620 kg/m^3	Solid	298.15	0
Thermal Expansion Coefficient	2.060×10^{-5} /K	Solid	298.15	

Thermal Properties		Conditions	
		Temp. (K)	**Pressure** (Pa)
Melting Temperature	1000.15 K		101325

Boiling Temperature	2170.15 K		101325
Critical Temperature	4450 K		
Fusion Enthalpy	52 J/g	0	101325
Vaporization Enthalpy	1019.46 J/g	0	101325
Heat Capacity	204 J/kg-K	298.15	100000
Thermal Conductivity	18.4 W/m-K	300	101325

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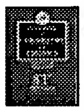

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Element Information: Chr

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Chromium

24	Atomic Number	24
Cr	Atomic Weight	51.9961
51.9961	Electron Config.	2-2-6-2-6-5-1

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Press
Density	7150 kg/m^3	Solid	298.15	
Modulus of Elasticity	248.211 GPa	Solid	0	
Poisson Ratio	0.31	Solid		
Thermal Expansion Coefficient	4.900×10^{-6} /K	Solid	298.15	

Electrical Properties		Condition
		Temp. (K)
Electrical Resistivity	1.290×10^{-7} Ω-m	273.15

Thermal Properties		C nditi ns	
		Temp. (K)	Pressui
Melting Temperature	2180.15 K		1013
Boiling Temperature	2944.15 K		1013
Critical Temperature	5500 K		
Fusion Enthalpy	404 J/g	0	1013
Heat Capacity	449 J/kg-K	298.15 more...	1000
Thermal Conductivity	93.7 W/m-K	300 more...	1013

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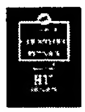
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Element Information: Pall

Palladium

46	Atomic Number	46
Pd	Atomic Weight	106.42
106.42	Electron Config.	2-2-6-2-6-10-2-6-10

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Press
Density	12000 kg/m^3	Solid	298.15	
Modulus of Elasticity	110.316 GPa	Solid	0	
Poisson Ratio	0.39	Solid		
Thermal Expansion Coefficient	1.180×10^{-5} /K	Solid	298.15	

Electrical Properties		Conditior
		Temp. (K)
Electrical Resistivity	1.080×10^{-7} Ω-m	293.15

Thermal Properties		Conditions	
		Temp. (K)	Pressur
Melting Temperature	1828.05 K		1013
Boiling Temperature	3236.15 K		1013
Critical Temperature	7700 K		
Fusion Enthalpy	157.3 J/g	0	1013
Heat Capacity	244 J/kg-K	298.15	1000
Thermal Conductivity	71.8 W/m-K	300	1013

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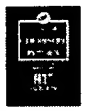

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Element Information: Ur

Uranium

92
U
238.0289

Atomic Number	92
Atomic Weight	238.0289
Electron Config.	2-2-6-2-6-10-2-6-10-14-2-6-10-3-2-6-1-.

Electron configuration order: *1s-2s-2p-3s-3p-3d-4s-4p-4d-4f-5s-5p-5d-5f-6s-6p-6d-7s*

Mechanical Properties		Conditions		
		Phase	Temp. (K)	Press
Density	19100 kg/m^3	Solid	298.15	
Modulus of Elasticity	165.474 GPa	Solid	0	
Poisson Ratio	0.23	Solid		
Thermal Expansion Coefficient	1.390×10^{-5} /K	Solid	298.15	

Electrical Properties		Conditions	
		Temp. (K)	Note
Electrical Resistivity	3.000×10^{-7} Ω-m		chrystallographic a

Thermal Properties		Conditions	
		Temp. (K)	Pressur
Melting Temperature	1408.15 K		1013:
Boiling Temperature	4404.15 K		1013:
Critical Temperature	12500 K		
Fusion Enthalpy	38.4 J/g	0	1013:
Heat Capacity	116 J/kg-K	298.15	1000(
Thermal Conductivity	27.6 W/m-K	300	1013:

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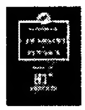

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PART B

SILICATE MMONOLITHICS, GUNNED SODIUM SILICATES

obert L. Trinklein

Hoeshoe Bend, Arkansas

Silicate corrosision-resistar cements as described in other sections of this is book are also availailable as gure grades. The sodium silicate systems include the ie two-part chemical l setting typ and the one-part modified system. The gunite e grades are applied l by pneumic gunning systems such as the Allentown, the ie Reed, or similar mananachines whh mix dry powder and liquid at the nozzle of the ie gun. This of coursese, necessitas the formulation of coarser aggregate mixes that it set much more rapioidly than mtar or castable silicates.

In guniting theiese mixes its generaly recommended that they be predamp-o-ened to reduce thene rebound ss and dusting. This is done by placing the dry y powder of the mix x either in anixer or through a conveyor type machine loader er where it is dampenened with a nall amount of liquid. The dampened material is is then mixed with mmore liquid the nozzle of the gun and impacted on the sur-r-face to be lined. UsUsually the ozzle is kept 3 to 4 feet from the surface and is is moved rythmically y in a serieof loops 6 to 9 inches high and 18 to 24 inches es wide as the materiaial is impactd perpendicularly on to the surface. The freshly y impacted material s should hava smooth shiny surface. A sandy granular surface e indicates that the n mix is toolry, whereas a rippling appearance indicates that at the material is too w wet.

These monolithithic gunite iings usually are single, large units, with or with-n-out expansion jointnts. They arapplied in thicknesses from ½ inch up to several al inches depending oron the servicrequirements. Linings one inch or more in thick-k-ness should be ancnchored witlstuds or with wire mesh that is adequately pro-o-tected. The anchoribring system necessary to retain the lining in contact with the ie

surface of the subsbstrate durir application, curing, and d service, anto distributete stresses to control d cure-crackig.

Gunited mononolithic soam silicates have been used for nny years asas linings for stacks, s, tanks, chineys, sewers, and otherer equipmer. They resistist most acids (excepıpt hydroflu ic and acid fluoride saltılts), moistuıand temperar-ature up to 1500°F°F. Perhaps e following advantages s have been sponsible foror their successful usese over the pt years:

(1) Monolithihic gunited ings can be applied verertically, ho:ontally, and overhrhead witha the need for complex x forms, suorts, or scaffolds. s.

(2) Curved oror irregular sfaces can be covered uniniformly.

(3) Gunned s sodium silice monolithic linings disisplay a tackess that improves s the bondinand densification of the e liner.

(4) They do n not give oftoxic fumes or odors duduring mixin applica-tion, and d setting.

Gunned monoolithic silicas of all types have somene limitatiorthat must bebe considered before e they can e successfully used. ThThey, like alcementitiousus materials, are infleflexible and nd toward brittleness. T The moduli of elasticityty ranges from 10^4 to:o 10^6 psi anflexural strength from 5600 to 2,000si dependinging upon the densificacation and fmulation. Similarly, tenensile streng ranges fromm 150 to 400 psi, a and comprsive strengths from 1,5000 to 4,00psi. Thermaal properties such as s coefficientf thermal expansion shoould be mated to that of of the substrate; howwever, whethis is not possible, a r membrane required bee-tween the lining arand the subrate to provide a slip-plalane and prent crackingng. In continuously wwet conditics a membrane should alslso be usedecause of thehe high diffusion ratate and absption of silicate materiarials. The thmal conducuc-tivity of a gunned d sodium silate lining is lower than that of ste or concretete. This is usually advdvantageous the lower temperature e on the sutrate reducees corrosion and thererrmal movemt.

In general, sosodium silica gunned linings have spspecific andnique advanan-tages as corrosion-n-resistant ceents; however, they musust be carefu formulated d, specified, and applplied to makthem cost effective.

Typical Phyhysical Proptties of Gunned Sodium h Silicate Marials

Compressiveve strength	4,500 pspsi
Tensile strerength	300 psi i
Cure shrinkkage	0.75%
Absorption n	1.25%
Coefficient t of thermalxpansion	11.8 x x 10^{-6} in/in/
Density	140 lb/f/ft^3
Flexural strtrength	240 psi i
Modulus of of elasticity	2.0 x 1 10^4 psi
Thermal coconductivity	3.7–4.8.8 Btu/ft^2/hF/in

PART C
GUNNE POTASSIUM SILICATE

Vlter Lee Sheppard, Jr.
C.R.M., Incorporated
Hertown, Pennsylvania

HISTORY AND LILIMITATIOS

Air spraying o of ceramic atings began well over half a century ago, startingng with hydraulic cenement formations. The procedures followed and the equip-p-ment used have u undergone nsiderable refinement, but only minor changes, over the years. Thihey are wellxpounded in Mr. Smith's section, and so will notot be repeated here. At some tie about mid-century, experiments were run usingng this same procedulure to applsodium silicate coatings, primarily as a lining foror the interior of stacicks and chineys venting acid-laden flue gases, and this type ofof lining is now frequently also en in high temperature ducting and in many otherer applications when n top tempetures are outside the economical limits of organioic linings. Mr. Trinklklein's shortaper gives the basic information on such currentnt sodium silicate usagage.

The three mosost importaılimitations of gunned silicate linings are probablyly (in this order) raththerhigh abrption, cure shrinkage, and swelling or growth—inin particular sulfatiorn-hydratioreactions. Like hydraulic mortars, all silicates re-e-quire water in the e mix, both or application and for the chemical reaction thatat "cures" or hardenns the mateal. When the water evaporates, it leaves a porousus structure behind. By careful rmulation of the mix and careful grading of thehe particle size, the mmanufacturcan reduce the size of these voids and so reducece the porosity, but he can nev eliminate it totally. Therefore, over a period ofof time, moisture in contact gas and water that condenses or collects on its sur-r-face will absorb ininto these vds and so eventually penetrate through the liningng and reach the subsbstrate, caring with it any chemicals (whether acid or not)t) that are dissolved i in the fluid

As gunned linining "cures"or hardens due to chemical action, it undergoes a a volume change. CuCure shrinka occurs in all concrete and other hydraulic mor-r-tars, but is higher ir in silicates.he shrinkage creates random stress in the materialal as it tries to pull it itself togetlr. If no provision is made for cure shrinkage, bothth cast concrete and d gunned lings can break up. To prevent concrete floors fromm breaking up, they a are reinford with rod or mesh. This same principle is followeded with gunned liningsgs.

The third liminitation—thof the sulfation-hydration growth chemical reac-c-tions—is peculiar toto all *sodiu* silicate compositions and has been discussed else-e-where in this volurume. Thoseesiring more details may find references for it inin the Bibliography at at the end this chapter. The only proven way to eliminate it it totally is to elimininate the soum. This can be done by changing from a sodiumm

silicate compositioron to a potsium silicate one, and to employ a hardener (a{a "catalyst") that corontains no scium.

It should not b be assumedıowever, that the total replacement of sodium byıy potassium will alscso eliminatall hydration growth reactions. Potassium mayıy form complex saltsts called alus in combination with a few other basic radicals—— including particulararly magnesm, iron and aluminum, combined with sulfuric ic acid. These alums s can pick umolecular water of crystallization and grow. Soio while the substitutution of potsium silicate for sodium will eliminate the greatat majority of growthth problemst may not eliminate all, and the designer shouldld bear this in mind ir in his studyf the anticipated environmental conditions of thee installation.

Although gunmned sodiursilicate mixes have been continuously availablele since this type of li lining was st investigated, no real effort seems to have beenn made to produce a a gunned passium silicate until fairly recently, due perhapsos to difficulty in getetting the thı available mixes to gun in a satisfactory manner,r, without excessive s sag and reund. A gunned 2-component potassium silicatete employing a sodiumm silicofluode hardener became available about 1980.

After an exterended perio of research, the first all-potassium (single com-n-ponent) mix becamme availablın 1978, largely through the combined efforts ofof Norman Huxley anand Ray Lea, and in 1980, U.S. Patent 4,227,932 was granted d on the design.

Hydraulic mororrtars (portlid and calcium aluminate cements), when placed d by gun, are usuallyly predamped with a small amount of water, and the balancee of the water is addded at the ızzle. The gunned all-potassium material is also a a single component, (, containingoray-dried potassium silicate and silica powder toto which water is addeded.

COMPOSITION ANND PROPETIES

The dry all-pototassium silite gunite formulation contains only dried potas-ıs-sium silicate, crushehed and grad silica, and the curing or hardening agent—which, ı, in this case, is a spspecially foıulated and patented condensed aluminum poly-y-phosphate. (For fururther detailsee *Chemically Resistant Masonry,* p 181, listed d in the Bibliographyıy) There arno other materials whatsoever in the formulation,n, and in application, ı, it is mixednly with clean, neutral potable water.

Typical physicical propertiafter placement are:

Compressive ststrength, 28 days (ASTSTM C-579)	3,100 psi (217 kp/cm^2)
Toluene absorprption	2.9%
Wet gunned dedensity	138 lb/ft^3 (2,208 kg/m^3)
Cured gunned d density	120 lb/ft^3 (1,923 kg/m^3)
Bond to steel	160 psi (11.2 kp/cm^3)
Tensile strengthth, 14 days	425 psi (29.7 kp/cm^2)
Flexural strengngth, 14 day	730 psi (51 kp/cm^2)
Linear shrinkacage	0.005 in/in unrestrained

Thermal condudductivity:	
at 280°F	4.4 Btu/ft^2/hr/°F/in (0.63 W/m/°C)
at 620°F	5.0 Btu/ft^2/hr/°F/in (0.72 W/m/°C)
at 1000°F	5.5 Btu/ft^2/hr/°F/in (0.79 W/m/°C)
Modulus of ela:lasticity	1.57 x 10^6 psi (1.1 x 10^5 kp/cm^2)
pH resistance n range	0 to 9
Maximum servrvice temperure	1650°F (900°C)
Coefficient of :f thermal exansion	7.0 x 10^{-6} in/in/°F (12.6 x 10^{-6} m/m/°C)

All data has b been basedn specimens resulting from actual gunning per-r-formed by a qualiility gunite pplicator. Water, air, and material feed pressureses were controlled. WWater and gning mix temperature were at ambient. Gunningng was performed onon flat, vertal panels. ASTM procedures, where applicableJe, were used for detetermination data. All data are subject to reasonable deviationon and should not, thetherefore, be:ed for specification purposes.

Actual field gugunning contions may vary and, therefore, yield different re-e-sults. These data a are presentd only as ideals and for comparing this mix withth another under idenmntical condions.

Because it is a a single dryomponent material, it can be stored in any con-n-venient ambient ststorage temrature as long as it is kept dry. Winter freezingng temperatures have e no effect iits storage life.

CURING

The mix takeses a rapid s after application (surface is hard in 15 minuteses after gunning), anand quicklylevelops strength and chemical resistance. It is is recommended, hovowever, thatt be allowed to cure for seven days undisturbeded at 70°F prior to plplacing in seice, and protected from the weather for at leastst the first two days.s. If it is de:ed to place the unit in service faster, this may bebe accomplished *afterer* the first 2 hours ambient cure, by heating at not more thanan 50°F (28°C) per hoour to the orking temperature, except that when the temper-r-ature of 250°F (12121°C) is reaed, the temperature must be held at that level foror six hours before raiaising it furter.

APPLICATION

Application shshould be mde with the substrate in the temperature range ofof 60° to 90°F (in noo case at a mperature below 50°F) and weather in the samee range, and should fl follow norml gunite procedures. The manufacturer provides a a detailed instructioron guide forhe benefit not only of the applicator, but also ofof the client, whose ir inspectors wl monitor the installation. Proper surface prepara-a-tion is obviously a a necessity.An anchoring and/or reinforcing system is alwaysys recommended. Steteel should l free of oil, grease, mill scale, rust, etc., with noo holes or voids and d all welds sooth and continuous, and sandblasted to a "com-n-mercial" finish (SSSSPC#6). Esting brickwork should be brush sandblasted toto remove all surface e contaminaon and loose material. Small deep holes and voidsds may require prepatatchings.

COMMERCIAL METALS AND ALLOYS

This table gives typical values of mechanical, thermal, and electrical properties of several common commercial metals and alloys. Values refer to ambient temperature (0 to 25°C). All values should be regarded as typical, since these properties are dependent on the particular type of alloy, heat treatment, and other factors. Values for individual specimens can vary widely.

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3. Shackelford, J. F., and Alexander, W., *CRC Materials Science and Engineering Handbook,* CRC Press, Boca Raton, FL, 1991.

Common name	Thermal conductivity W/cm K	Density g/cm³	Coeff. of linear expansion 10^{-6}/°C	Electrical resistivity μΩcm	Modulus of elasticity GPa	Tensile strength MPa	Approx. melting point °C
Ingot iron	0.7	7.86	11.7	9.7	205	-	1540
Plain carbon steel AISI-SAE 1020	0.52	7.86	11.7	18	205	450	1515
Stainless steel type 304	0.15	7.9	17.3	72	195	550	1425
Cast gray iron	0.47	7.2	10.5	67	90	180	1175
Malleable iron		7.3	12	30	170	345	1230
Hastelloy C	0.12	8.94	11.3	125	200	780	1350
Inconel	0.15	8.25	11.5	103	200	800	1370
Aluminum alloy 3003, rolled	1.9	2.73	23.2	3.7	70	110	650
Aluminum alloy 2014, annealed	1.9	2.8	23.0	3.4	70	185	650
Aluminum alloy 360	1.5	2.64	21.0	7.5	70	325	565
Copper, electrolytic (ETP)	3.9	8.94	16.5	1.7	120	300	1080
Yellow brass (high brass)	1.2	8.47	20.3	6.4	100	300-800	930
Aluminum bronze	0.7	7.8	16.4	12	120	400-600	1050
Beryllium copper 25	0.8	8.23	17.8	7	130	500-1400	925
Cupronickel 30%	0.3	8.94	16.2		150	400-600	1200
Red brass, 85%	1.6	8.75	18.7	11	90	300-700	1000
Chemical lead	0.35	11.34	29.3	21	13	17	327
Antimonial lead (hard lead)	0.3	10.9	26.5	23	20	47	290
Solder 50-50	0.5	8.89	23.4	15	-	42	215
Magnesium alloy AZ31B	1.0	1.77	26	9	45	260	620
Monel	0.3	8.84	14.0	58	180	545	1330
Nickel (commercial)	0.9	8.89	13.3	10	200	460	1440
Cupronickel 55-45 (constantan)	0.2	8.9	18.8	49	160	-	1260
Titanium (commercial)	1.8	4.5	8.5	43	110	330-500	1670
Zinc (commercial)	1.1	7.14	32.5	6	-	130	419
Zirconium (commercial)	0.2	6.5	5.85	41	95	450	1855

Elastic essence ticket of metal

The Table of Modulus of Elasticity about Metal

Gold inside Metal		Bulk modulus K [kgf/cm ^{2}]	Elastic modulus E [kgf/cm ^{2}]	Modulus of transverse elasticity G [kgf/cm ^{2}]	phu With song rain ν
Li	Lithium	1.39 X 10 ^{5}	1.17 X 10 ^{5}	0.43 X 10 ^{5}	0.36
Na	Sodium	0.83 X 10 ^{2}	0.91 X 10 ^{2}	0.35 X 10 ^{2}	0.32
K	Potassium	0.41 X 10 ^{2}	0.36 X 10 ^{2}	0.13 X 10 ^{2}	0.35
Be	Beryllium	1.28 X 10 ^{3}	3.16 X 10 ^{3}	1.50 X 10 ^{3}	0.05
Mg	Magnesium	3.39 X 10 ^{2}	4.52 X 10 ^{2}	1.77 X 10 ^{2}	0.28
Al	Aluminum	7.46 X 10 ^{2}	7.19 X 10 ^{2}	2.72 X 10 ^{2}	0.34
Ti	Titanium	1.26 X 10 ^{3}	1.08 X 10 ^{3}	4.05 X 10 ^{2}	0.34
Zr	Zirconium	9.15 X 10 ^{2}	9.75 X 10 ^{2}	3.68 X 10 ^{2}	0.33
Hf	Hafnium	1.12 X 10 ^{3}	1.41 X 10 ^{3}	5.40 X 10 ^{2}	0.30
V	Vanadium	1.65 X 10 ^{3}	1.30 X 10 ^{3}	4.76 X 10 ^{2}	0.36
Nb	Niobium	1.67 X 10 ^{3}	1.06 X 10 ^{3}	3.73 X 10 ^{2}	0.38
Ta	Tantalum	2.11 X 10 ^{3}	1.88 X 10 ^{3}	7.00 X 10 ^{2}	0.35
Cr	Chromium	1.94 X 10 ^{3}	2.40 X 10 ^{3}	9.00 X 10 ^{2}	0.30
Mo	Molybdenum	2.80 X 10 ^{3}	3.47 X 10 ^{3}	1.22 X 10 ^{3}	0.30
W	Tungsten	3.19 X 10 ^{3}	3.96 X 10 ^{3}	1.51 X 10 ^{3}	0.29
Mn	Manganese	1.27 X 10 ^{3}	2.02 X 10 ^{3}	7.80 X 10 ^{2}	0.24
Fe	Iron	1.72 X 10 ^{3}	2.17 X 10 ^{3}	8.47 X 10 ^{2}	0.28
Co	Cobalt	1.87 X 10 ^{3}	2.04 X 10 ^{3}	7.63 X 10 ^{2}	0.31
Ni	Nickel	1.87 X 10 ^{3}	2.05 X 10 ^{3}	7.85 X 10 ^{2}	0.31
Cu	Copper	1.40 X 10 ^{3}	1.25 X 10 ^{3}	4.64 X 10 ^{2}	0.34
Ag	Silver	1.02 X 10 ^{3}	8.05 X 10 ^{2}	2.94 X 10 ^{2}	0.38
Au	Gold	1.75 X 10 ^{3}	8.02 X 10 ^{2}	2.82 X 10 ^{2}	0.42
Zn	Zinc	6.17 X 10 ^{2}	9.40 X 10 ^{2}	3.79 X 10 ^{2}	0.29
CD	Cadmium	4.85 X 10 ^{2}	6.35 X 10 ^{2}	2.46 X 10 ^{2}	0.30
In	Indium	4.45 X 10 ^{2}	1.07 X 10 ^{2}	0.38 X 10 ^{2}	0.46
Tl	Thallium	3.71 X 10 ^{2}	0.81 X 10 ^{2}	0.28 X 10 ^{2}	0.46
Si	Silicon	3.22 X 10 ^{3}	1.15 X 10 ^{3}	4.05 X 10 ^{2}	0.44
General Electric	Germanium	7.11 X 10 ^{2}	1.01 X 10 ^{3}	4.00 X 10 ^{2}	0.28
Sn	Tin	5.20 X 10 ^{2}	5.54 X 10 ^{2}	2.08 X 10 ^{2}	0.33
Pb	Lead	4.22 X 10 ^{2}	1.66 X 10 ^{2}	0.57 X 10 ^{2}	0.44
Sb	Antimony	4.00 X 10 ^{2}	5.60 X 10 ^{2}	2.04 X 10 ^{2}	0.28
Bi	Bismuth	3.60 X 10 ^{2}	3.48 X 10 ^{2}	1.31 X 10 ^{2}	0.33

Reference : W. K ö ster and H. Franz : Metallurgical Review, 6 (1961)